Feasibility of Air-Cooled Condenser Cooling System

for the

Standardized AP1000 Nuclear Plant

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Southern Company Generation
Engineering & Construction Services

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Westinghouse AP 1000 Nuclear Plant
Air Cooled Condenser - Design Review

Attorney Work Product prepared in anticipation of litigation.

Introduction

The philosophy behind the AP1000 Nuclear Plant is to standardize on a plant design for the nuclear power industry which would increase the viability of nuclear power as an energy source, while reducing time of construction, licensing, as well as reducing total plant cost. The standard AP1000 plant cooling system design includes a closed loop cooling system with a traditional steam surface condenser to condense steam from the turbine and a wet evaporative cooling tower. Cooling water is re-circulated from the tower to the condenser (for condensing steam) as the media for heat transfer from condensed steam from the turbine. Air flow through the cooling tower transfers heat to the air via evaporation of warm water (as a steam/plume leaving the cooling tower).

Southern Nuclear was questioned as to whether they had considered an alternate type of system such as an air cooled condenser (ACC) to condense steam from the turbines. This type of system uses air as the main heat transfer media instead of water and as such is perceived to have less impact on aquatic resources than the traditional closed loop cooling system currently included with the AP1000 nuclear plant design.

Scope

The scope of this study was to review the design of the AP1000 cooling system with the conventional steam surface condenser and investigate the design of a comparable air-cooled condenser (ACC) to support the generic design concept for the AP1000 Nuclear Plant design for a unit to be deployed at the Vogtle Electric Generating Plant. The results of this study will be used to compare an ACC system with the traditional wet cooling system currently specified for use as the normal heat sink for an AP 1000 nuclear plant. This study encompasses initial cost differentials, station service requirements, and O&M differentials over the life of the plant for the different options.

AP1000 Cooling System Conceptual Design

The conceptual design for the cooling system for the AP1000 Nuclear Plant was developed by Westinghouse/Toshiba. The primary initiative of the AP1000 Nuclear Plant is to promote a generic standardized design for use at all potential sites and for all potential clients. The standardized plant design would facilitate and expedite the licensing, procurement, construction, and commercial operation of for all the standardized units. The Nuclear Regulatory Commission has repeatedly expressed its desire that the next generation of nuclear plants be standardized, including the balance of plant beyond the nuclear island. See Draft Statement of Policy on Conduct on New Reactor Licensing Proceedings 72 Fed. Reg. 32139. 32142 (“the Commission encourages applicants to standardize the balance of their plants insofar as is practicable). Based on this initiative, Westinghouse and Toshiba conceptualized the design of the turbine island and cooling system components as described in the following sections.

Turbine Generator Design for AP1000 w/Steam Surface Condenser

In the current configuration of the AP1000 Nuclear Plant, steam is passed across a steam turbine and the turbine turns a generator, creating electricity. The steam leaves the turbine and goes to a steam surface condenser, a large heat exchanger filled with tubes that have cold water flowing through them. The cold water in the tubes absorbs the heat from the steam, causing it to condense back into liquid form; it is then pumped back to the nuclear reactor and the process begins again. The cold water circulating through the condenser tubes is pumped out to a wet cooling tower where it is cooled off by dumping its heat to the surrounding air. Once cool, the water is pumped back through the condenser tubes. Both circuits continue in a continuous process (hence the name – “closed loop cooling system”).

The turbine generator on the AP1000 nuclear plant is a triple exhaust turbine which simply means that steam from the turbine(s) will exhaust into three separate steam surface condenser shells. These are generally referred to the high pressure, intermediate pressure, and the low pressure turbines. For optimum plant efficiency, the multi-pressure turbine generator for the AP1000 nuclear plant is designed to have the following backpressures as indicated below (from DCP/NUS0302).

HP Turbine backpressure	3.57 “HgA
IP Turbine backpressure	2.82 “HgA
LP Turbine backpressure	2.37 “HgA
Avg. Turbine backpressure	2.92 “HgA

Normal operation of the turbine generator was assumed to be within an exhaust pressure (backpressure) range of ~ 1.0 to 5.0 “HgA. The higher the backpressure on the turbine, the less electricity the generator is able to produce, while the lower the backpressure is on the turbine, the more electricity the generator is able to produce (down to choke flow backpressure @ ~ 1.0 “HgA).

The turbine generator is located on a concrete pedestal above the steam surface condenser which allows steam to be routed directly from the turbine to the condenser below. The exhaust duct carrying the steam to the condenser is called the turbine hood which is simply a distribution/transition piece from the turbine to the surface condenser below. Minimizing the pressure losses in the hood from the turbine to the condenser is important to avoid loss of turbine efficiency and MW output. The design of the entire turbine island (thermal cycle) depends on the turbine and condenser performance.

The powerhouse building design is dependent on the turbine and condenser arrangement, size, and configuration. The turbine pedestal supports the turbine with the steam surface condenser located directly under the turbine and pedestal. The design of the turbine extraction piping, location of feed-water heaters, and condensate pumps is largely dependent on turbine and condenser design and location.

The configuration of the triple exhaust turbine requires the steam surface condenser to also be segmented into three shells, similarly called the high pressure (HP), intermediate pressure (IP), and low pressure (LP) shells. The average pressure of the three condenser shells (HP+IP+LP)/3 is the key parameter for unit performance considerations and operating limitations on the turbine generator. Figure 1 shows a schematic of the turbine and steam surface condenser configuration. Figure 1 also shows the cooling system of an AP1000 Nuclear Plant for Vogtle 3 & 4 depicted with a conventional steam surface condenser and a Natural Draft Cooling Tower.

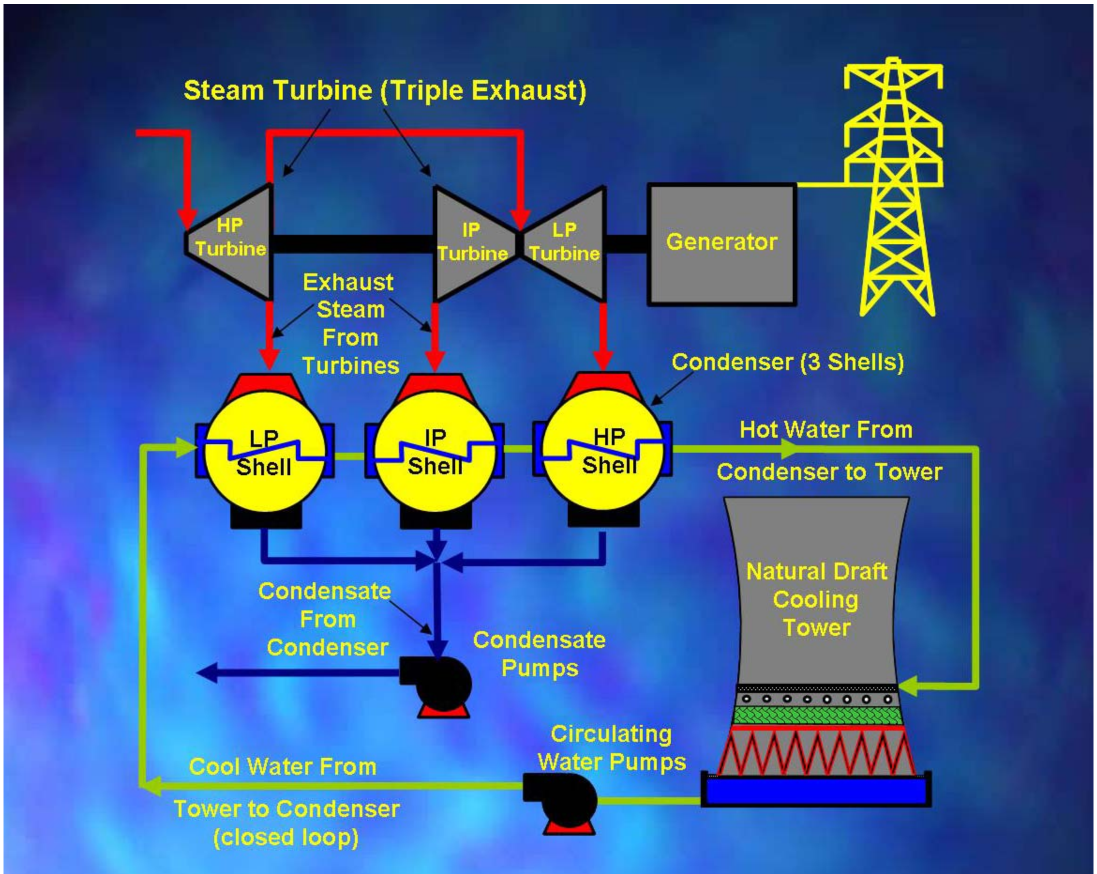


FIGURE 1
Schematic of AP1000 Closed Loop Cooling System
Steam Surface Condenser (Triple Pressure/3 Shell) Configuration
(3 shells = High Pressure, Intermediate Pressure, Low Pressure)

Cooling Tower Design

The cooling tower was designed based on operating parameters provided by Westinghouse/Toshiba. Because the AP1000 design does not have a standard cooling tower design and a final decision has not been made as to which type of wet cooling tower will be utilized at the Vogtle site, this study investigated both mechanical draft and natural draft cooling tower designs. Each tower design operates similarly to use air to cool the circulating water coming from the condenser; they differ only in the means of moving the air through the tower. A mechanical draft cooling tower uses large fans to force the air through itself while a natural draft tower uses the differential air density between hot and cold air to create a draft effect similar to that of a chimney on a fireplace to pull air through itself. Both are considered viable design options for an AP1000 plant at the Vogtle site.

Current cooling tower design conditions:

Design cooling water flow:	600,000 gpm
Design hot water temperature:	115.2°F
Design tower range:	25.2°F
Design dry bulb temperature (natural draft):	96.1°F
Design wet bulb temperature:	80°F
Design tower approach:	10°F
Design cold water temperature:	90°F

A mechanical draft tower usually accommodates an average cell flow of ~ 12,500 GPM to 13,000 GPM per tower cell. As such, a mechanical draft tower is anticipated to be sized as follows:

Design cooling tower flow:	600,000 GPM
Number of tower cells	48 Cells
Number of towers	2 Towers w/ 24 Cells Per Tower (2x12) 3 Towers w/ 16 Cells Per Tower (2x8) 4 Towers w/ 12 Cells Per Tower (2x6)
Fan Hp/Cell	200 HP / 175 kW
Total Tower Fan Power	9,600 HP / 7,162 kW

Figure 2 shows a typical natural draft cooling tower installation and Figure 3 shows a typical mechanical draft tower installation for an 800 Mw coal fired unit.


Figure 2
Typical Natural Draft Cooling Tower
(Two - 800 Mw Units)


Figure 3
Typical Mechanical Draft Cooling Tower
(~ One - 800 Mw Unit)

Steam Surface Condenser Design

Figure 4 shows a typical steam surface condenser for the AP1000 nuclear plant which was conceptualized by Westinghouse/Toshiba to have the following design parameters:

Type Condenser:		Multi-pressure, Single Pass, Three Shell
Design Tube Material		Titanium
Design Tube O.D. / Tube Gage		1.0 " O.D / 22 BWG
Design Tube Velocity		8.2 FPS
Design Flow		600,000 GPM
Design Heat Load (MBtu/Hr)		7,565.2 Btu/Hr x 10^6
Design Inlet Cold Water Temperature		91.0 °F
Design Range (Delta T - ° F)		25.2 °F
Design Surface Area		1,235,737 Sq. Ft.
Design TTD - ° F		5.33 °F
Design Pressures	High Pressure (HP) Shell	3.57 "HgA
	Intermediate Pressure (IP) Shell	2.82 "HgA
	Low Pressure (LP) Shell	2.37 "HgA
	Average (Avg.) Shell Pressure	2.92 "HgA

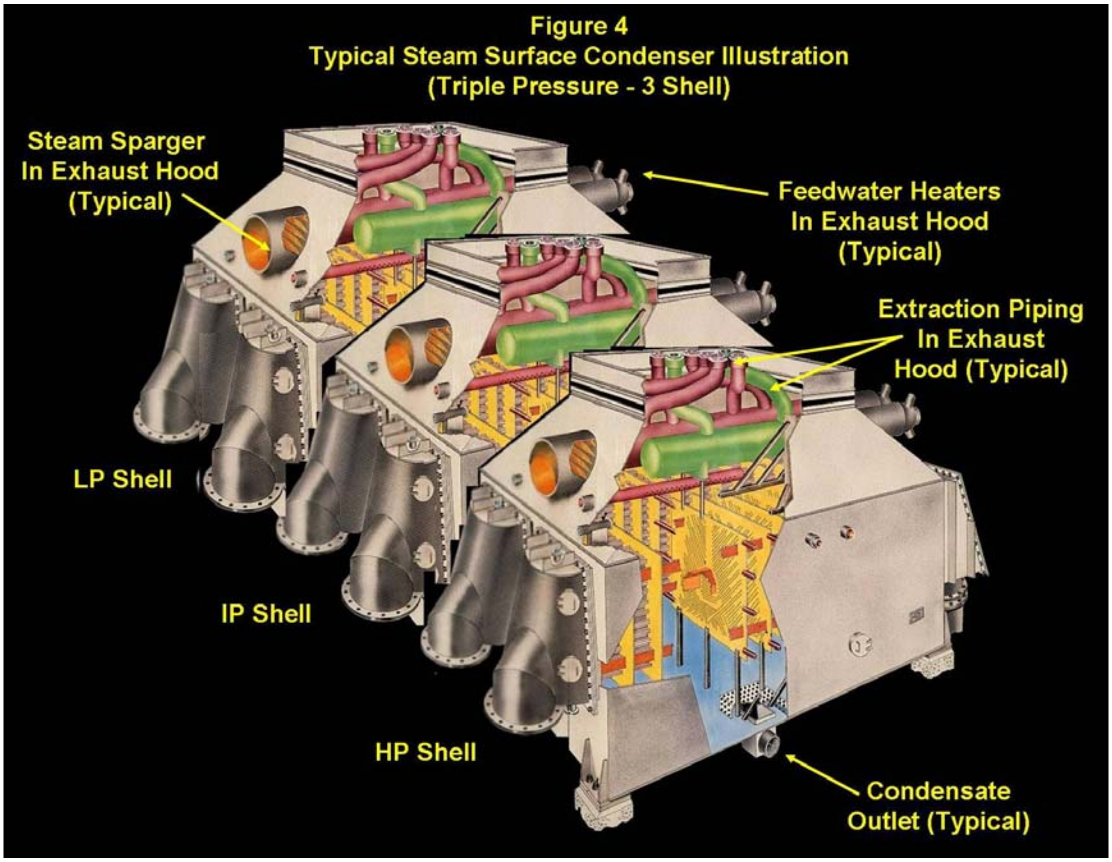
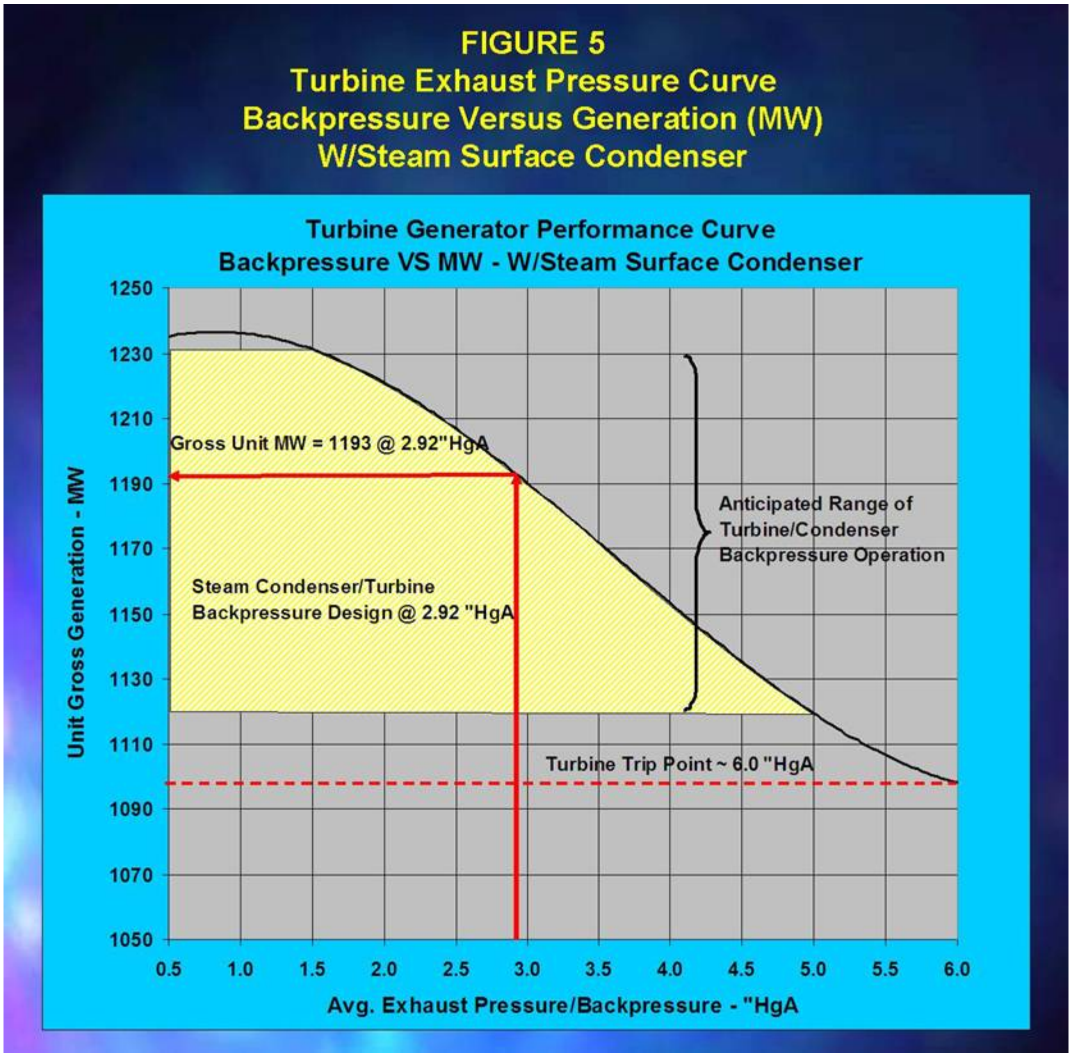


Figure 4
Typical Steam Surface Condenser Illustration
(Triple Pressure - 3 Shell)

The steam surface condenser design was modeled and verified for performance based on the Heat Exchange Institute (HEI) Standards (9th edition). Figure 4 shows the exhaust hood(s) from the HP, IP, and LP turbines to the steam surface condenser. Figure 4 also shows the steam surface condenser with feed-water heaters (FWH) installed in the exhaust hoods which saves on piping and building cost/space. This practice is common on Nuclear plants with large condensers which enables proficient use of space in the exhaust hoods rather than requiring additional building space.

Figure 5 shows a turbine backpressure curve versus unit generation (MW). Figure 5 also shows the condenser average design pressure of 2.92 “HgA superimposed on the turbine exhaust backpressure curve. Figure 5 shows the gross unit generation of the unit to be ~ 1,193 MW at the turbine/condenser backpressure of 2.92 “HgA. The net unit (gross minus internal station service MW) generation is closer to ~ 1,000 MW which is the basis for the unit nameplate rating (i.e. AP1000).



<u>Current Air Cooled Condenser Technology Is Not Compatible With the Standard AP1000 Turbine</u>

With an air-cooled condensing system, the steam leaving the turbine is piped through large ducts (16 to 20 Ft. diameter+) outside of the building to an air-cooled condenser (ACC) where it is condensed by air flowing over large metal-finned tubes. The heat from the water is rejected directly to the air and atmosphere. Similar to a mechanical draft wet tower, an ACC uses fans to force air across the finned tubes to achieve optimum heat transfer. Each set of a fan and bank of finned tubes is typically referred to as a module. As it rejects its heat, the steam condenses to water and is drained to a large tank from which it is pumped back to the nuclear steam supply system. Figure 6 attached shows a schematic of the turbine exhaust and ACC configuration for a theoretical AP1000 unit.

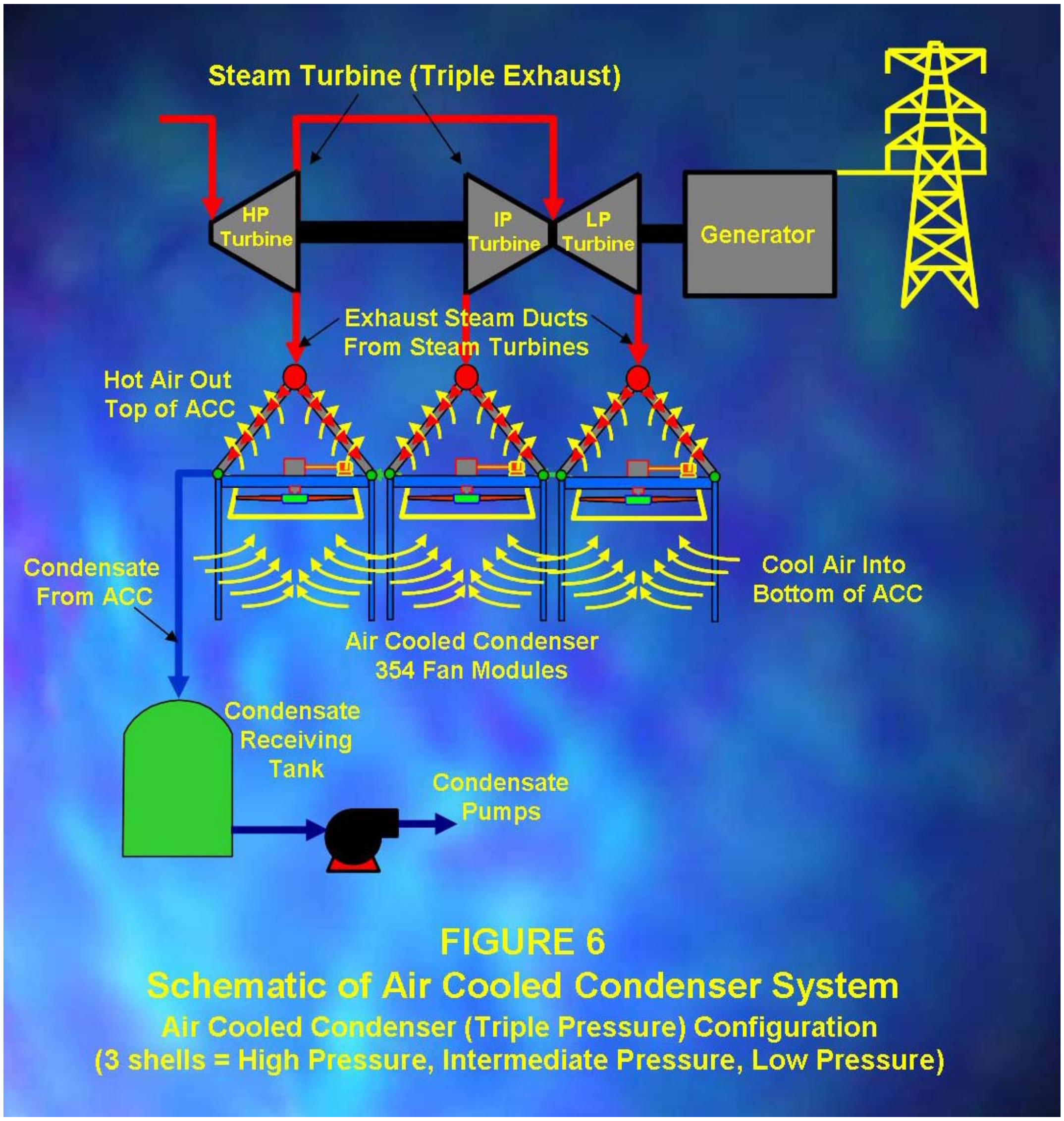


FIGURE 6
Schematic of Air Cooled Condenser System
Air Cooled Condenser (Triple Pressure) Configuration
(3 shells = High Pressure, Intermediate Pressure, Low Pressure)

While simpler than a wet system, the lack of an intermediate step in the heat rejection process an air-cooled system poses several likely insurmountable design issues for its use in an AP1000 in lieu of a wet system. To begin with, unlike a wet system, an air-cooled system does not include an additional buffer between the nuclear supplied steam and the environment. If tube leaks develop within the ACC, the nuclear supplied steam is released directly into the ambient air. More importantly from a plant performance standpoint, an ACC is not as thermally efficient as a wet system. The wet system can utilize the water as a cooling medium and capitalize on its evaporative heat transfer, something the dry system cannot do. Due to this degradation in efficiency, an air-cooled system must be significantly larger than a comparable wet system to maintain the same unit performance. Because of these limitations, air-cooled systems have typically been built in the United States on smaller, combined-cycle type units with much lower heat loads than an AP1000 unit. As discussed in more detail below, we have no experience with such systems on large nuclear facilities such as the AP1000.

The chief governing design characteristic of an ACC is the Initial Temperature Difference (ITD), the difference between the temperature of the outside air and the temperature of the steam condensing within the tube bundles. ITD also impacts the steam saturation temperature and therefore the backpressure on the turbine, which is another limiting design characteristic of a steam turbine. Current “state-of-the art” air-cooled condensers for the utility industry are designed with an ITD of around 40^{o}F, although there have been a few ACCs built in the United States with an ITD of 35^{o}F. No manufacturer of air-cooled condensers has successfully designed or built an air-cooled condenser with a lower ITD than this. The minimum ITD is a material limitation on the technical feasibility of an ACC system in conjunction with the AP1000 steam turbine, especially when the peak ambient temperatures in the vicinity of Plant Vogtle and the maximum backpressures at which the standard AP1000 turbine will operate are taken into account.

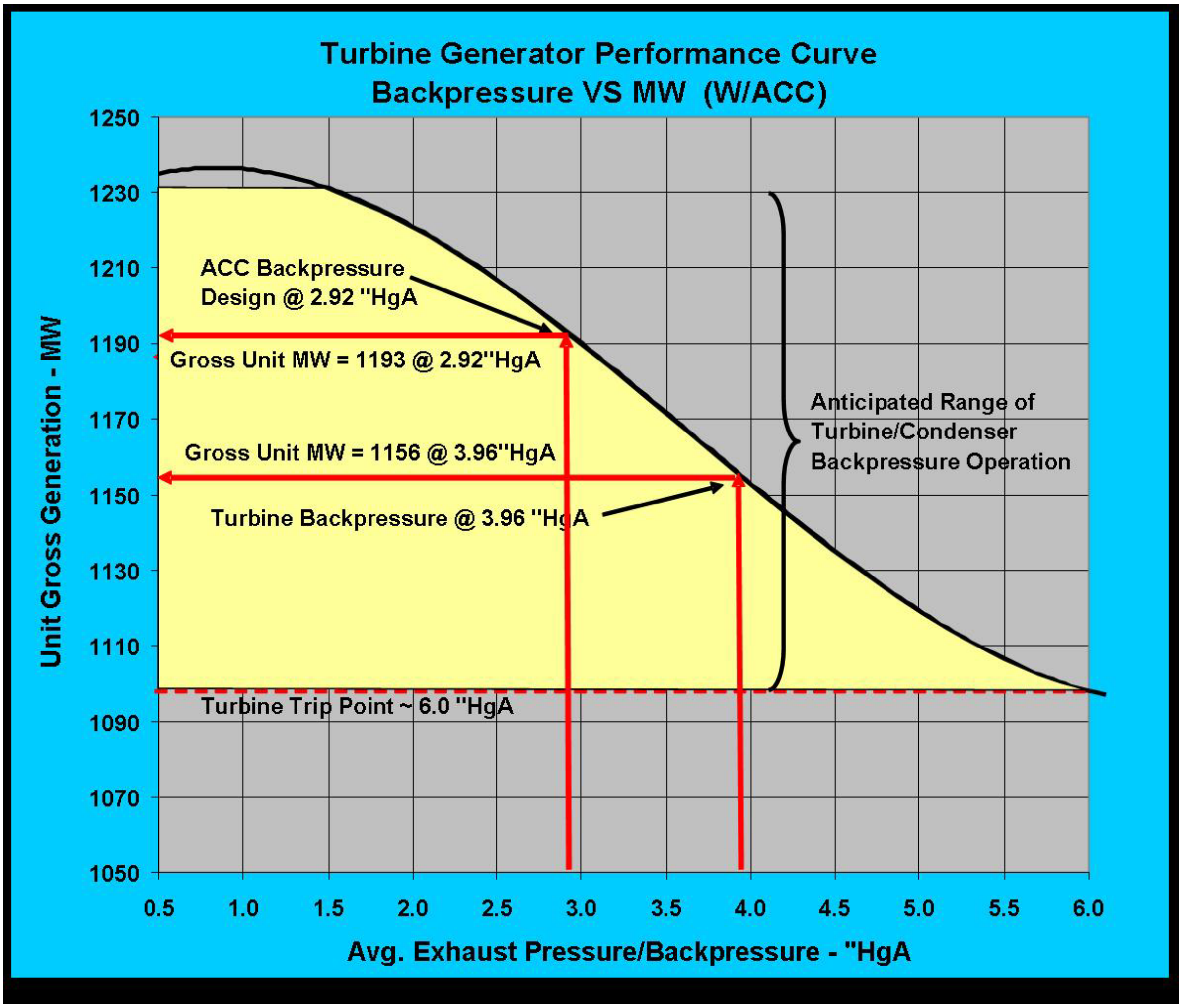
Steam turbines are designed to trip off line to prevent damage to the turbine if the exhaust backpressure rises above a certain set point. The turbine trip point for the AP1000 design was assumed to be at a backpressure of ~ 6.0 “HgA with alarm set point at 5.0 “HgA. This effectively limits operation to conditions which will keep the turbine at a pressure below 5.0” HgA, which corresponds to a steam saturation temperature of approximately 133.5^{o}F. This is problematic to an ACC design because when calculating back using the current limit of technology (a 35ºF ITD) then theoretically the best ACC could be constructed at the Vogtle site would have a backpressure of over 4.5” HgA at the design ambient temperature of 95ºF. While this is nominally not in excess of the upper end of turbine’s operational limit, it presents three major issues.

First and foremost, steam duct losses from the turbine outlet to the ACC tube bundles (estimated at 0.5-1.0” HgA at a minimum) would drive the backpressure at the turbine outlet to the point that that the turbine would see a pressure in excess of its allowable operating pressure. This would cause the unit to have to come off-line at the time when system demand was at its peak. Such a limitation on the operability of an ACC system is not acceptable from a reliability standpoint for a base load generating facility in southern Georgia.

Secondly, even if the ACC could be physically located closely enough to the turbine outlet to keep duct losses to a minimal value the ACC would not function with the currently designed AP1000 turbine. As described, the turbine operates at three distinct pressures. Even if one section of the ACC could be designed as above, the other two sections would have to operate at higher design pressures to correspond to the two higher pressure sections of the turbine. Certainly one, and most likely both of these sections, would have design pressures higher than the turbine trip point, again rendering the turbine inoperable at times of peak system demand.

While it would theoretically be possible to construct all three sections of the ACC to operate at the same design pressure, and for that pressure to be at or near the 4.5" HgA listed above, this would be a substantial deviation from the AP1000 standard design since this would force the turbine to operate at a single backpressure. Similarly, the turbine design could be changed to allow for operation at higher backpressure limits than those of the current turbine design. However, even if this were possible (and to the best of our knowledge no one has ever built a triple pressure turbine that could operate continuously at pressures higher than 5" HgA), it would be yet another substantial deviation from the AP1000 standard design.

Third, any increase in backpressure below the trip point for the current turbine would result in a substantial reduction in output. For example, assuming an *average* turbine backpressure 4" HgA could be achieved using an ACC in conjunction with the standard AP1000 turbine, which as noted above could not be achieved during the periods of the year in which the unit was needed most, the result would be a loss of around 40 MW out of the generator as compared to operation at the current design backpressure of 2.92" HgA.



A Theoretical Air-Cooled System That Would Be Compatible With The AP1000 is Not Feasible From A Reliability, Cost, or Environmental Standpoint

The current reality is that an air-cooled system is not technically feasible (or even possible) for an AP1000 unit constructed at the Vogtle site. However, in an effort to demonstrate a comparison of the cost and land use requirements of an ACC that would replicate the current performance of a wet cooling system for an AP1000 unit at the Vogtle site, an assumed ACC was theoretically designed. The theoretical system was assumed to have a condensing steam temperature of just over 114^{o}F (the saturation temperature of steam at the pressure of 2.92" HgA used in the current Westinghouse wet cooling system design). Since the design ambient temperature for the Vogtle site is 95^{o}F then the design ITD of the ACC is would be *less than 20^{o}F; i.e. more than 40% less than the minimum ITD using current technology!* It cannot be overstated that this is a purely academic exercise and that it is not now, nor would it seem to be in the foreseeable future, technologically feasible to construct an air-cooled condenser that can replicate this performance. If the system could be constructed and designed, its design parameters would be as follows:

ACC Design Steam Flows (Lb/Hr)	HP Shell	2,626,248 Lbs./Hr
	IP Shell	2,433,080 Lbs./Hr
	LP Shell	3,100,072 Lbs./Hr
	Total Steam Flow	8,159,400 Lbs./Hr
Total Number of Modules		334
Number of Rows of Modules		54
Modules Per Row		6
Fan Power Per Module		189.5 HP / 141.3 kW
Total ACC Fan Power		61,390 HP / 45,797 kW
Design Heat Load (MBtu/Hr)		7,565.2 Btu/Hr x 10^6
Design Ambient Temperature		95.0 °F
Design Pressure		2.92"HgA

As an example of potential size, Figure 8 shows an ACC designed for 10.0 'HgA with 30 modules for a **220 Mw steam turbine**. Designing an ACC for 2.92" for the same 220 MW turbine would require 66+ modules. In comparison, the design of the ACC for an AP1000 plant at the Vogtle site with a 2.92 "HgA condenser backpressure will require ~ 334 modules with a fan power of ~ 180 BHP per module.
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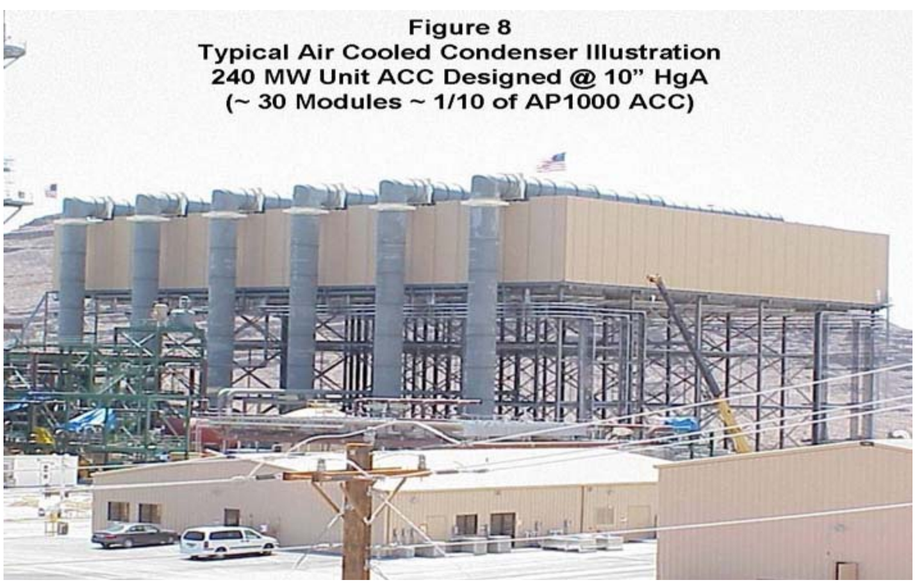
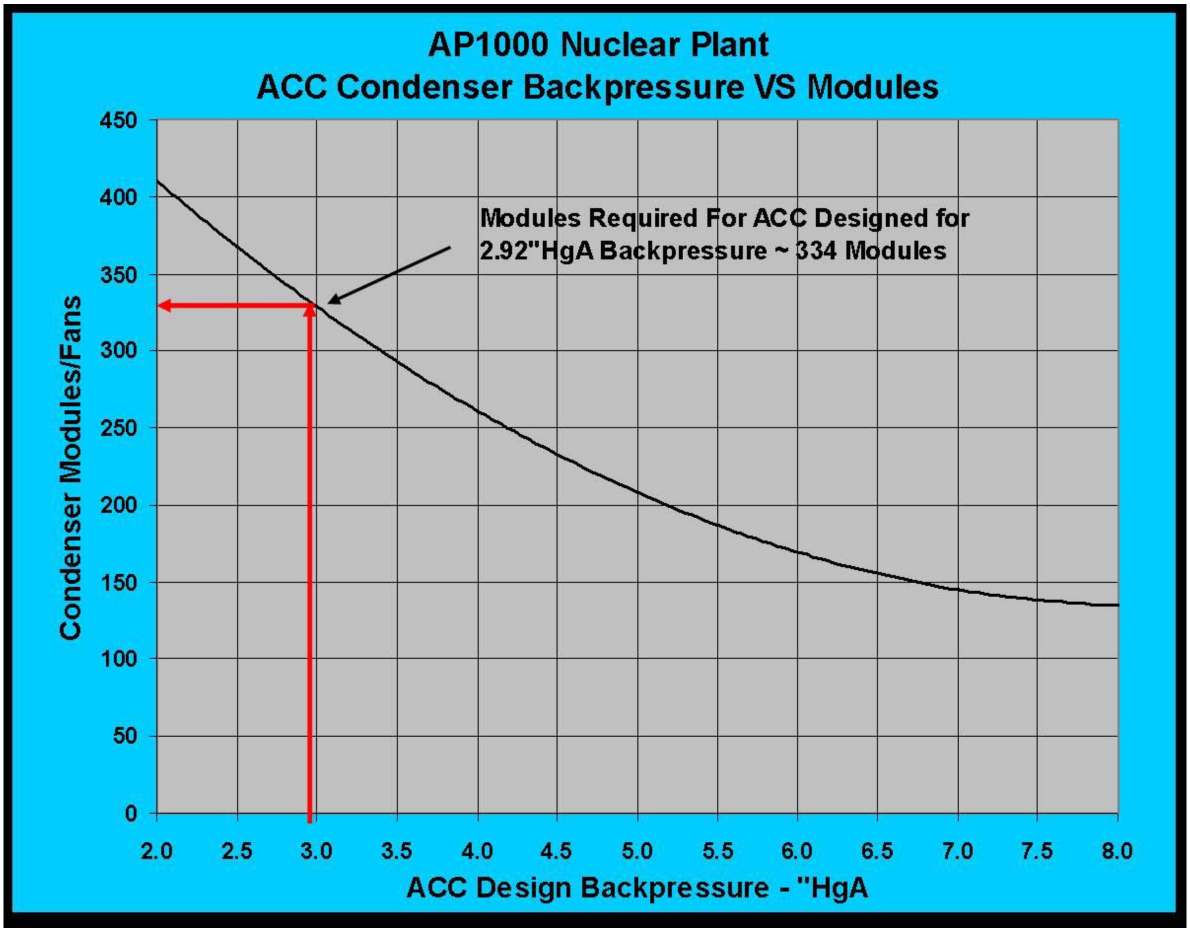
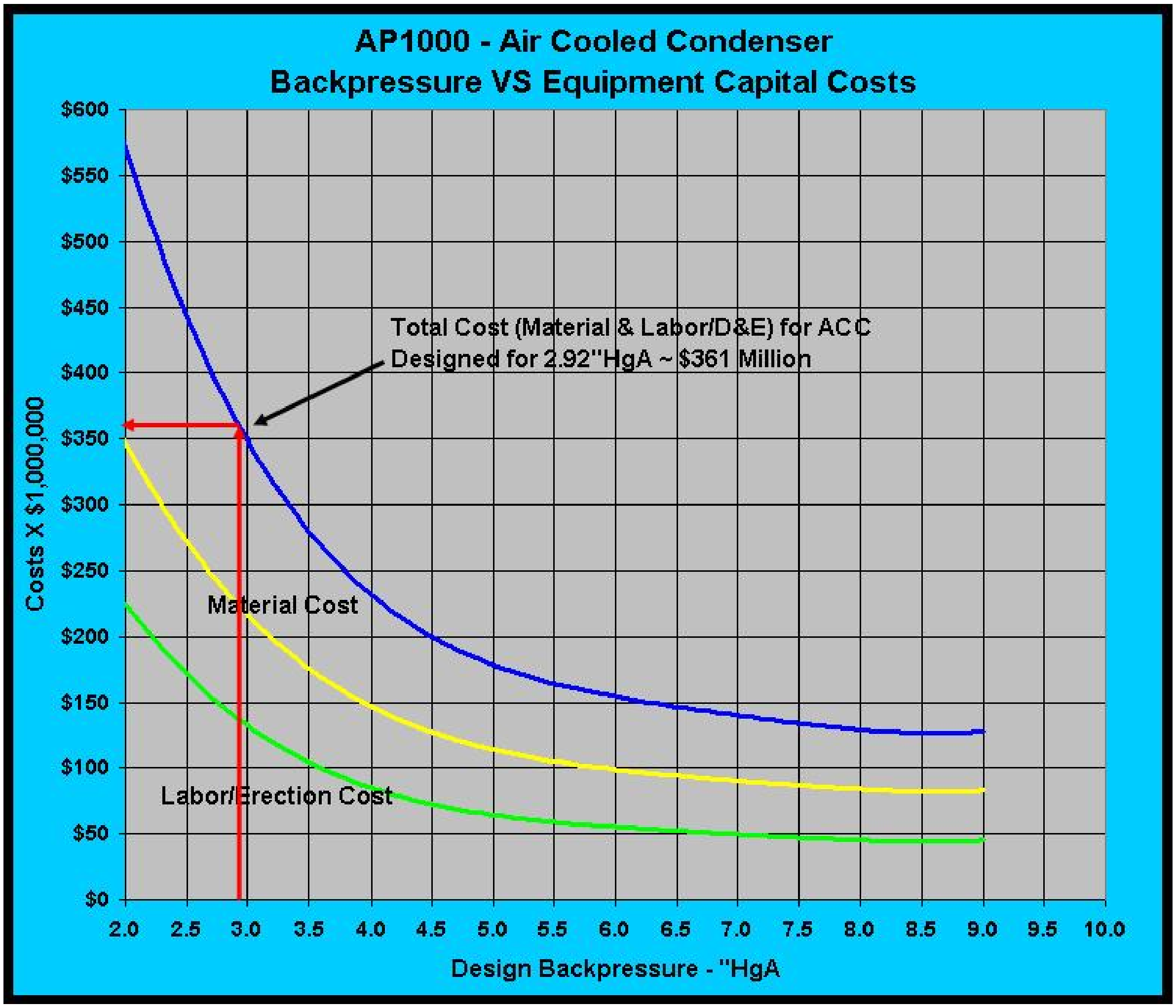


Figure 8
Typical Air Cooled Condenser Illustration
240 MW Unit ACC Designed @ 10" HgA
(~ 30 Modules ~ 1/10 of AP1000 ACC)

Figure 9 shows the number of ACC modules/fans required as a function of ACC design backpressure for the AP1000 design.

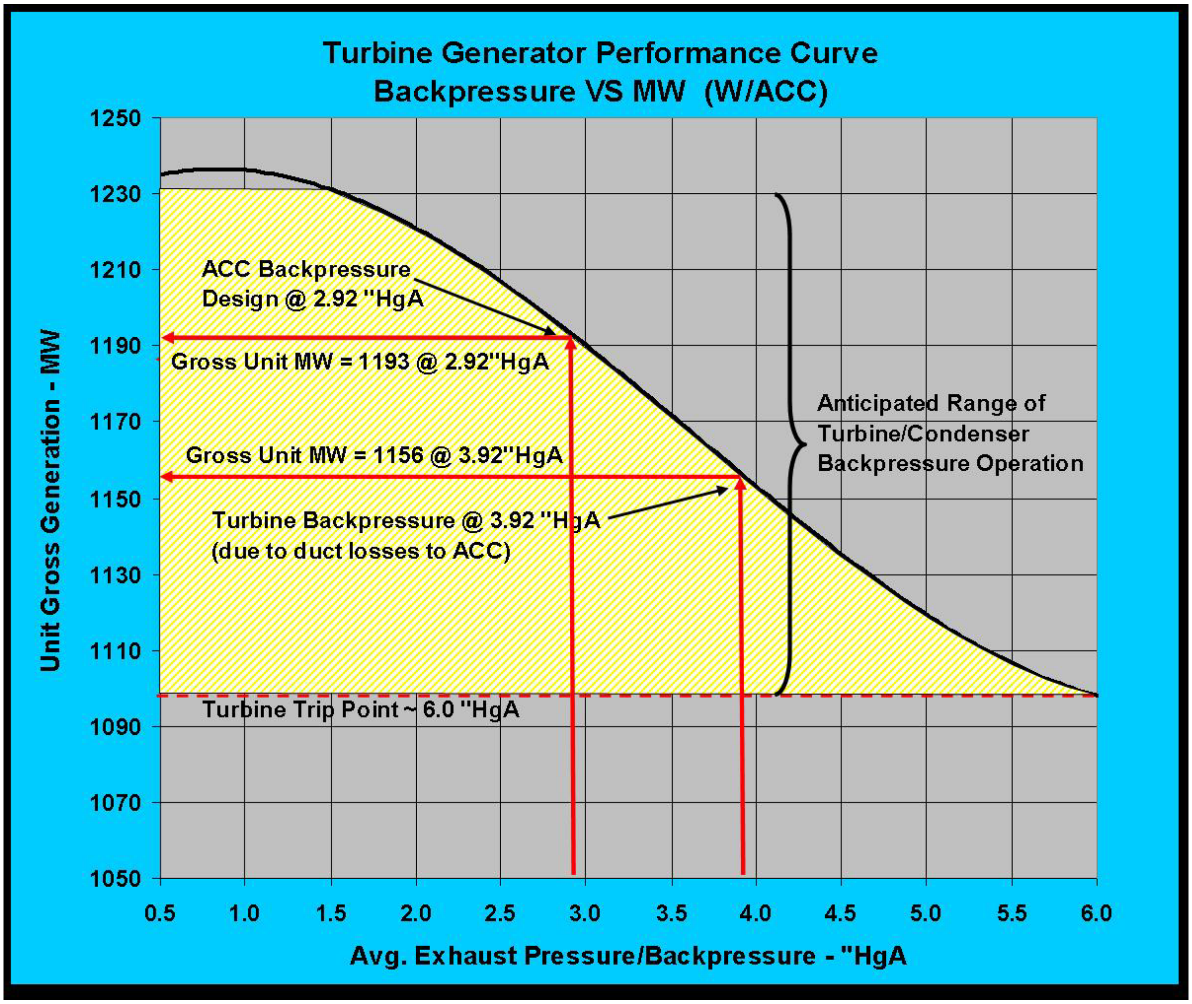


The fan power energy (station service) requirements for the 324 modules of the ACC was estimated to be ~ 44,095 kW (~ 44 MW) which reduces the net unit generation output. Figure 9 shows the cost of an ACC for the AP1000 plant as a function of ACC design backpressure. Based on the above design parameters, the capital cost for the ACC with 334 modules designed for 2.92” HgA was determined to be ~ $361,000,000.



<u>Additional Impacts to the AP1000 Design with an ACC</u>

If an ACC were to be designed for an AP1000 unit, the entire turbine building would have to be reworked. In place of the current steam surface condenser, three large ducts would have to be constructed beneath the turbine. These ducts would then have to be run through the walls of the turbine building and outside to a distance a minimum of 100 feet away prior to routing the ducts to individual sections of the ACC up to 2000 feet away. This would necessitate changes to the wall of the turbine building and potentially the turbine pedestal. It could also cause layout changes to other equipment in order to provide a path for the steam ducts. The incremental losses in backpressure through these ducts could be as high as 0.5 to 1.0" HgA resulting in a turbine backpressure as high as 3.92 "HgA. Figure 10 shows the turbine gross generation capability @ 3.92 "HgA to be 1,156 MW which translates to a reduction in gross turbine capability of ~ 37 MW (from ~ 1,193 MW @ 2.92 "HgA). Additional ACC modules could theoretically be added to offset the degradation in performance from steam duct line losses. However, this would increase both the capital cost and station service requirements exponentially (see previous cost curve). Moreover, any benefits of standardization outside the nuclear island between Plant Vogtle and other AP1000 units would be lost or seriously compromised.



Layout and real estate requirements for the AP1000 ACC design are very large as stated previously. The maximum depth of bays (parallel to air inlet) was limited to 6 modules deep due to airflow anomalies on an ACC. ACC orientation is critical with regard to predominant wind direction. Figure 12 shows the number of modules required per turbine exhaust section.

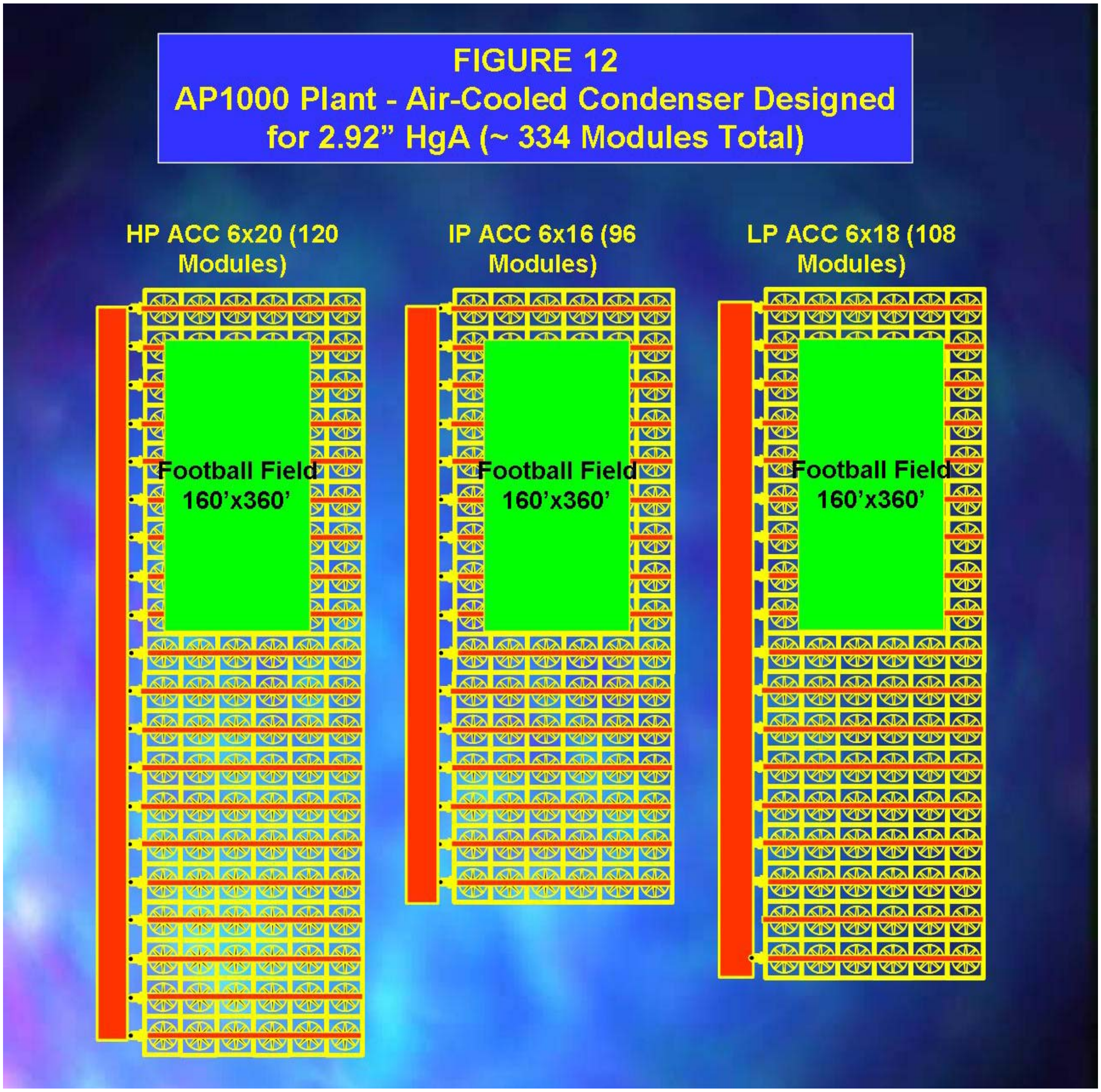


Figure 13 shows the layout and size requirements for the complete ACC installation which is approaching > ½ mile in total length. This obviously requires a substantial long and expensive steam duct routed from the powerhouse to the ACC.

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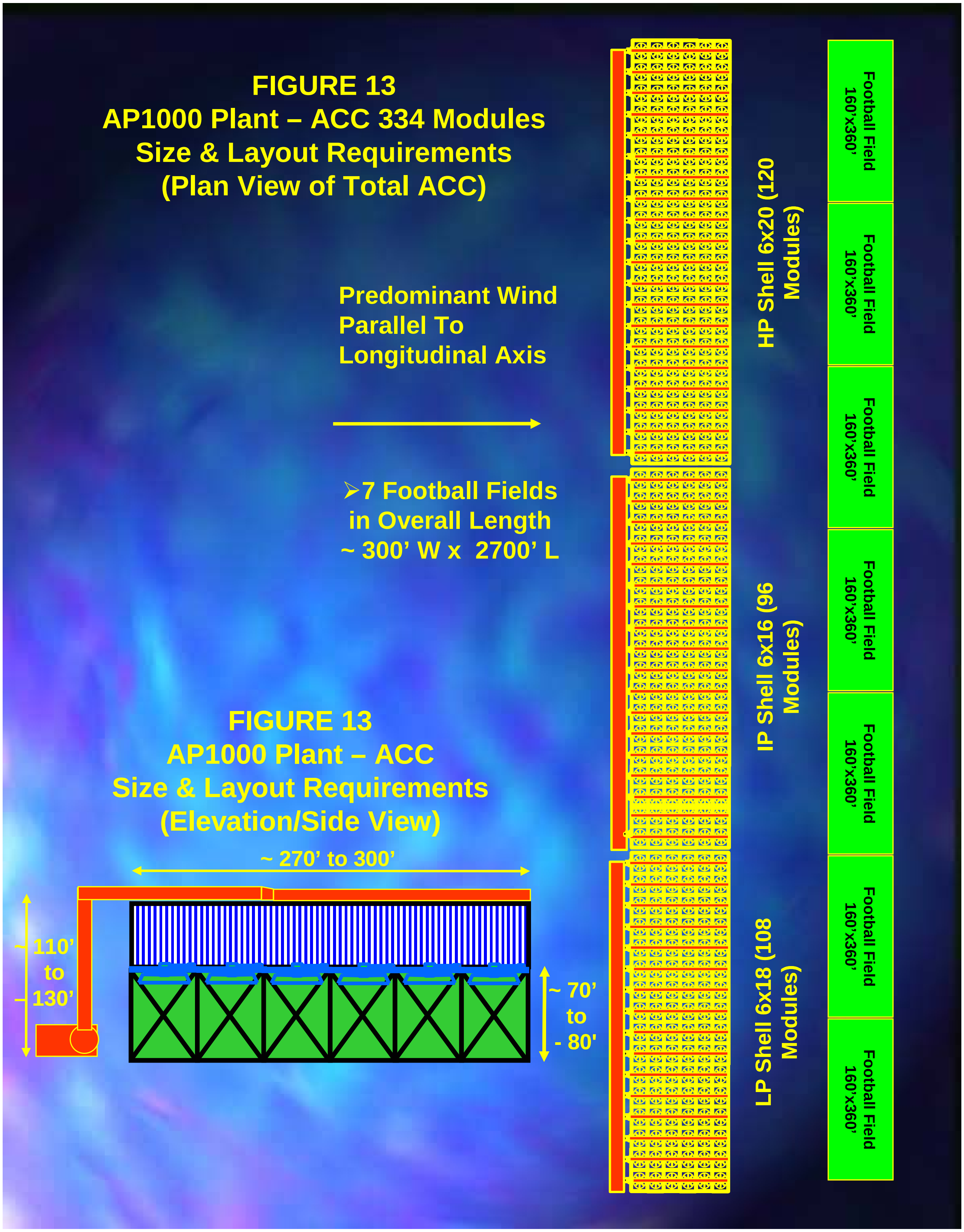

Another change that an ACC would certainly necessitate is to relocate the feed-water heaters that are currently designed to be placed in the neck of the steam surface condenser as shown in Figure 4. Since there would no longer be an exhaust hood in the steam surface condenser in which to mount them, the heaters would have to be moved to a different location within the turbine building. No attempt was made to estimate the cost impacts of the layout changes, but they would require significant engineering hours. The changes would also represent significant further deviation from the standardization of the AP1000 design.

It should also be mentioned that air-cooled condensers operate in correlation with the dry-bulb temperature of the air, which can vary as much as 20-30 degrees in a day. This wide variance can cause difficulties operationally, as the condenser backpressure will then also fluctuate widely throughout the day. For a nuclear unit, which typically would be a base loaded unit with a high capacity factor, such swings could cause unit instability and/or system-wide instability.

Cost Comparisons

The impact on turbine building and powerhouse was not assessed due to the magnitude and complexity of system changes (i.e. feed-water heater system, condensate system, etc.). Additional equipment costs were also not assessed for an ACC such as condensate storage tanks, air removal systems, piping and auxiliaries which are anticipated to be substantial. The design and cost of the steam duct from the ACC to the turbine was also not captured due to the ACC design being beyond current applied technology. A comparison of the cost for an ACC versus a steam surface condenser on a closed loop cooling system are shown in the attached Appendix.

Equipment prices shown here are budgetary in nature and based solely on the information provided by ACC Vendors and Southern Nuclear. In the event an actual plant was to be designed and built, potential changes in building design, real estate, ACC ductwork, and associated subsystems would increase the cost substantially for an ACC installation and widen the differential from the cost for a conventional system designed with a steam surface condenser (existing design concept).

Results/Conclusions

The cost for an air-cooled condenser is approximately five times greater than the cost of a comparable wet cooling tower and steam surface condenser on a closed loop cooling system.

The design of the ACC requires substantial real estate above the standard plant design (site area > 0.5 miles wide per unit).

The reduction in net unit output with the use of an ACC was estimated to be ~ 81 MW (37 from lines losses and 44 from fan energy). Additional station service energy requirements required with an ACC may require changing plant nameplate from AP1000 to AP900.

Sizing the ACC to match the AP1000 steam surface condenser performance is purely academic which by no confirms that such an ACC could even be actually designed and/or built. The lack of any experience with an extremely large ACC on a multi-pressure turbine suggests caution in assuming viability of concept.

It should be noted that utilizing an ACC will require substantial changes to the standard AP1000 powerhouse building, turbine pedestal, steam piping, as well as numerous other equipment and subsystems which further substantiates that utilization of an ACC (if technically viable) will require a site specific custom plant design.

In summary utilization of an ACC in conjunction with the deployment of an AP1000 unit at the Vogtle site is not feasible from the standpoint of technical viability, unit reliability, unit performance, or cost.

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APPENDIX – Data Comparisons

	80F Wetbulb 11F Approach Natural Draft	80F Wetbulb 11F Approach Mechanical Draft	95F Drybulb 2.92 "HgA Design BP Air-Cooled Condenser
Design Condenser Flow - GPM	600,000	600,000	N/A
Design Tower Wetbulb (Deg.F)	80	80	N/A
Design Tower Approach (Deg.F)	11	11	N/A
Condenser Design CWT (Deg.F)	91	91	N/A
Condenser Design BP ("HgA)	2.92	2.92	2.92
Design Range (Deg.F)	25.2	25.2	N/A
Condenser Design HWT (Deg.F)	116.2	116.2	N/A
Number of Tower Cells/ACC Modules	N/A	48	324
Number of Tower/ACC Fans	N/A	48	324
Tower Fan HP	N/A	9600	58,320
Tower Capital Cost	$48,000,000	$21,000,000	N/A
Tower Pumping head	50	38	0
Steam Surface Condenser Cost	$45,000,000	$45,000,000	N/A
Circulating Water Pump Cost	$5,000,000	$5,000,000	N/A
Air-Cooled Condenser Cost	N/A	N/A	$350,000,000
Total Equipment Capital Costs (2007$)	$98,000,000	$71,000,000	$350,000,000
Station Service Requirements			
Circulating Water Pump TDH (Ft. Water)	95	85	N/A
Circulating Water Pump SS (kW0	13,298	11,898	N/A
Cooling Tower Fan SS (kW)	N/A	7161.6	N/A
Air Cooled Condenser Fan SS (kW)	N/A	N/A	43,507
Turbine BP Degradation (ACC Duct Losses) - (kW)	N/A	N/A	7200
Total SS - (kW)	13,393	19,145	50707
Worth of SS ($/kW) - Assumed	$5,996	$5,996	$5,996
Differential In Station Service Cost	$0	$34,488,056	$223,734,968
Unit Performance			
Turbine Exhaust BP - "HgA	2.92	2.92	2.92
Turbine Gross Generation @ BP (kW)	1,190,150	1,190,150	1,190,150
SS Requirements	13,393	19,145	50,707
Adjusted Turbine Gross Generation (kW)	1,176,757	1,171,005	1,139,443
O&M Requirements			
Annual Fan/gearbox repairs	N/A	$120,000	$810,000
Fan Gearbox replacement	N/A	$600,000	$4,050,000
Fan Motor Rewinding	N/A	$200,000	$1,350,000
Freeze Protection Repairs	$50,000	$30,000	$202,500
ACC Tube Cleaning	N/A	N/A	$500,000
Maintenance Totals	$50,000	$950,000	$6,912,500
GRAND TOTAL	$98,050,000	$106,438,056	$580,647,468

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